Heliophysics Technology And Instrument Development For Science

The Development of a Groundbreaking Geomagnetic Field Remote Sensor for the Study of Ionospheric Current Systems

Completed Technology Project (2018 - 2020)

Project Introduction

In this project we will make laboratory assessment of the performance of the digital spectrometer, a key subsystem of a 118-GHz spectroradiometer designed to measure global E-region magnetic fields (B) from space. Accurate B field measurements are critical to understand the interactions between Earth and near space and the coupling processes within the atmosphere, ionosphere and magetosphere system, one of the key scientific challenges identified in Solar and Space Physics: A Science for a Technical Society, authored by the National Research Council Committee on a Decadal Strategy for Solar and Space Physics (Heliophysics) in 2012 (HDS). The main mechanism that couples these different geospace systems is the field-aligned current or the Birkeland current at high latitudes that flows along the B field lines and the intense electric current above the dip equator that flows perpendicular to the B field lines. Generated either in the magnetosphere (auroral electrojet) or within the thermosphere/ionosphere (equatorial electrojet), these currents close in the ionosphere as Pedersen and Hall currents in a thin layer near 100-150 km altitudes. They are very difficult to measure from in-situ sensors because it is too high for balloons and too low for satellites. Understanding the coupling between Earth and near Space coupling is therefore severely hindered by the lack of direct measurements of these currents in this thin layer. Lacking the critical observations leave fundamental questions unanswered despite four decades of research. The Microwave Electrojet Magnetogram (MEM) instrument, to be developed and subsystem tested under this proposed Heliophysics Technology and Instrument Development for Science Program (HTIDS) investigation, will measure for the first time the B field strengths generated in the electrojet current regions. It resolves the three Zeeman-split O2 thermal lines at 118 GHz and provides simultaneous B field (from spectral split and polarization), neutral wind (from spectral shift), and temperature (from spectral brightness temperature) measurements globally at altitudes right below the current closure altitudes under all solar and atmospheric illumination conditions. Together these measurements provide critically needed observational constraints to the complex electrodynamics processes in the coupled atmosphere/ionosphere/magnetiosphere system. MEM unequivocally supports the science objectives of future Heliophysics missions dedicated to address challenging and unanwered questions identified in the 2012 HDS report. In addition, MEM is an uncooled, low power and compact sensor, ideal to support future cost-effective science missions in implementing the HDS DRIVE (Diversify Realize, Integrate, Venture, Educate) initiative. The MEM instrument development and performance demonstration effort is a joint project between The Johns Hopkins University, Applied Physics Laboratory and NASA Goddard Space Flight Center. The MEM development leverages on mature technology of the MLS/Aura instrument and recent advances in the 118-GHz polarmetric sensor technology. Because scientific payloads on future NASA Heliophysics missions is likely resource-limited and cost-constrained, in this proposal we will design the optimal receiver architecture of the MEM instrument and assess

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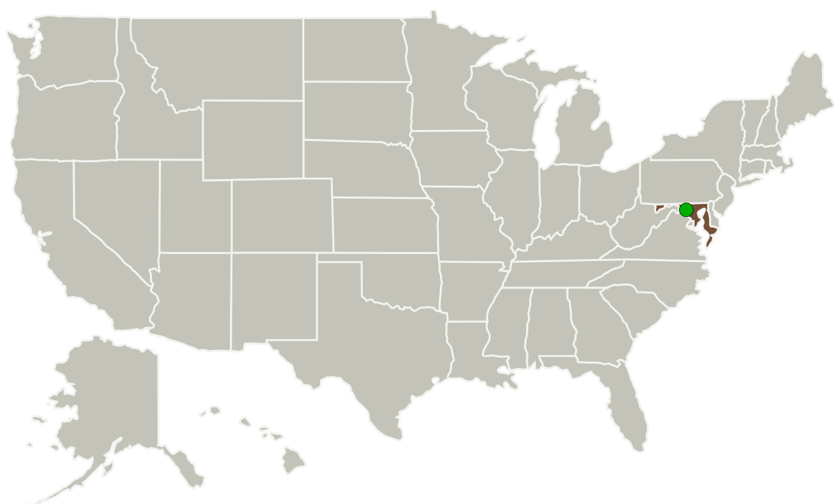
the performance of its compact, low-mass, and low power digital spectrometer. Under the proposed 24-month project (2/1/18 to 1/31/20), we will mature technology level of the MEM backend digital spectrometer system to meet both Heliophysics science and programmatic requirements. The successful completion of this proposed HTIDS project will not only reduce implementation risk/cost for future geospace missions, but also shorten the instrument development time.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Johns Hopkins University	Lead Organization	Academia	Baltimore, Maryland
Applied Physics Laboratory	Supporting Organization	Industry	Laurel, Maryland
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Supporting Organization	R&D Center	Laurel, Maryland

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Johns Hopkins University

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Jeng-hwa Yee

Co-Investigators:

Dongliang Wu
Felicia Hastings
Jesper W Gjerloev
Norman H Adams
Paul E Racette
John D Boldt

Primary U.S. Work Locations

Maryland

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **6**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

The Sun